E/CONF.39/D/55
8 Oct. 1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: D.9.3

Czechoslovakia

NEW ENGINEERING TECHNIQUES

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NEW ENGINEERING TECHNIQUES

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1. Introduction

(a) Engineering techniques and their further development are to a great extent influenced by the steady advance of automation and mechanization.

(b) The automation and mechanization of the mechanical engineering industries are undergoing an impetuous development in all countries and attention is in the first place concentrated on the classical techniques of machining and working, i.e. on machine operations.

(c) A certain lag in the progress of automation and mechanization can be observed in assembly and manual work generally and especially in small-lot and piecework production. Therefore for the present time the mutual relation of the four major engineering techniques - i.e. machining, chipless forming (pressing and forging), welding and manual and assembly work - should be taken for a criterion of the level of engineering techniques.

(d) The technological set-up is the basis of production and will remain so in the future. It has a deciding influence on the level of engineering production and should create such conditions as will enable the production to go on in all its stages in the most economic manner, to ensure the planned volume of production and to guarantee the top quality of products.

(e) In general it is possible to say that the technological level of mechanical engineering production is determined in the first place by:

(i) directing research and development work towards the advancement of the technological level of production;

(ii) introducing highly progressive techniques and efficient organization in the production processes of mechanical engineering industries;

(iii) the level of production machinery and equipment and the load factor.

(f) The elaboration of the engineering techniques development problems must proceed in the closest connection with scientific research. Also operation research is very important, especially the cost analysis of preparing times in machine operations.

(g) An accomplished analysis of technological processes from the point of view of the preparing time costs enables us then to set down several basic principles for the mechanization of clamping and gauging operations in machining. In the Czechoslovak mechanical engineering industries such thorough analyses have been performed and now it can be said that in some fields which will be discussed further this question has already been solved, to a great extent successfully. It is in particular in the fields of machining, chipless working and welding where mechanization has made the greatest advance.

2. Machining

(a) In machining, mechanization and automation is represented by programme-controlled machine tools.

(b) Piece-work and small-lot production require a "flexible" automation, i.e. easy, speedy and economic methods of adapting a fully or partly automatic machine to the production of another type of workpiece.

(c) One of the new tendencies which is being applied in the automation of this type of production is the introduction of speedy adjustable machines of which at present the programme-controlled machine tools are the representatives.

(d) The programme usually contains information on the shape and size of the workpiece, on machining techniques, cutting conditions, and other necessary production functions. For recording the programme and supplying it to the machine different media can be used, e.g. punch card, punched tape, magnetic tape with pulse or phase modulated record etc.

(e) In general it is possible to say that the greater number of functions such a programme-controlled machine is able to automatically perform the more intricate it is and the heavier demands it will make on maintenance work whereas the actual attendance work becomes much simpler. For the full utilization of programme-controlled machines a new organization of production is necessary; the organization must ensure continuous running of production so as to avoid time loss. These machines can find advantageous application above all in the production of intricate-shaped workpieces where much machining is needed and which make heavy demands on accuracy.

(f) According to the accomplished economic analyses the programme-controlled machine tools exhibit as a rule a high efficiency in many cases even in case when one operator runs only one single machine. E.g. the semi-automatic vertical copying lathe SPK 63 shows in comparison with the conventional vertical lathe with a table 800 mm dia. an increase in productivity of 162 per cent. In this case the time of investment returnability is 2.15 years.

(g) The efficiency of the programme-controlled machines increases substantially when they are combined into technological groups or lines thus enabling one operator to run more machines.

(h) Some programme-controlled machine tools of Czechoslovak make have already been working for longer periods of time in engineering works and many more types of programme-controlled machine tools reached the stage of development or in some cases prototypes are available. These are mostly machines provided with digital control and representing altogether more complicated programme-controlled machine tool types. The application of digital control provides the possibility of continuous movement of the tool allowing an intricate plane or space trajectory. In addition to the control of the direction and sense of movement and the length of the trajectory, i.e. to the determining of the shape and size of the workpiece, it is possible to apply digital control also to the feed and cutting speed. The movement of the tool or of the workpiece is set out in the programme by a series of numerical data which are determined from an engineering drawing of the respective part and supplied to the machine recorded e.g. on a punched tape. This numerical information carries the working

programme of the machine and represents a formula according to which a special electronic computing control equipment generates the prescribed number of electrical impulses. The character, number and rate of the impulses controls both the feed and the trajectory length of the tool or workpiece.

(j) The advantages of programme-controlled machines are as follows:

(i) One worker can run several machines;
(ii) The programme can be prepared separately apart from the machine;
(iii) Products are geometrically identical;
(iv) The preparing times can be minimized; tool performance can be utilized to the full;
(v) Several workpieces can be machined simultaneously in one cycle
(vi) The programme-control enables a speedy setting-up and therefore these machines are fit for application both in piece-work and small-lot production;
(vii) It is possible to store the tape with the recorded programme for future needs.

(k) The application of programme-controlled machine tools marks the principal trend in introducing automation in the field of piece-work and small-lot production. The preparation of production is changed into programming where machining conditions must be determined separately (i.e.apart from the machine); this method demands a substantially higher qualification of technologists in charge of programming. Grouping together workpieces with similar production technologies facilitates the organization and preparation of production for different machine tool types.

(l) In order to increase labour productivity programme-controlled machines are being gradually equipped with automatic clamping and loading devices, storage bunkers, tool replacing devices, accurately adjustable tools for speedy elimination of edge wear and with automatic gauging.

(m) The efficiency of programme-controlled machine tools has not only the direct effect of increasing productivity but also secon-

dary effects that can not be taken into account in the evaluation of total costs savings. The most important of these secondary effects include: increase in the all-plant productivity, attainment of higher production accuracy, improvement of labour conditions, savings of labour and the possibility of dividing the whole-year output into smaller batches.

(n) The programme-controlled machine tools represent a new trend in the production technique which is progressive; it is therefore necessary to prepare further conditions for its successful introducing into production.

3. Chipless Working

(a) In the field of chipless working of materials, one of the problems that have been studied in Czechoslovakia, is the question of production techniques of parts with a through-hole. A new process of manufacturing such parts has been developed and tried out in practice. The new technology is covered by the Czechoslovak patent No.91509. More than 90 per cent of material are utilized when the process is applied. In comparison with machining approx. 62 per cent of material are saved. This technology has been tried out with success and used for producing small parts of motor cars, tractors and bicycles. The possibilities of its application are, of course, much wider.

(b) To produce parts with a through-hole, it is necessary, first, to prepare semi-products, i.e. welded rings of wire of desired cross-section. Carbon steels or low-carbon alloy steels with guaranteed weldability are being used. If the part is held in another clamp and is, itself not subjected to tensile stresses, it may be pressed from welded rings. Otherwise, the rings must be welded; butt-welding is used. Flashes resulting from welding are removed by pressing the weld in a die and by trimming the side-flash.

(c) Wire having a cross-section in the desired shape and size serves as base material. In order to keep the volume of the material within close tolerance limits, such as are required in cold working, it is necessary to use wire of H 11 tolerance. Preparation of rings can be best carried out on machines (wire or spiral spring coiling machines). The wire is wound to a helix; individual coils

are cut off and flattened to plane rings by pressure in the machine. Among the machines suitable for this work, we may mention e.g. Czechoslovak universal automatic spring-coiling machines AU 3 for wire of 0.8-3 mm dia., TAU 50 for 2-5 mm, or AU 8 for 3-8 mm dia. wires.

(d) Further preparation of rings consists in descaling (tumbling), degreasing and phosphatizing with subsequent impregnation of the phosphate layer with a lubricant. These operations are the same as in other cold working processes.

(e) The use of rings as a semi-product yields large material savings and a substantial reduction of working time. This process results in lighter stressing of the tool and thus its longer life. The circular or eliptical cross-section of the ring has the following effect: the working part of the tool, i.e. the punch and the die do not contact at the beginning of the working process the whole active surface of the ring, the contact being theoretically only in a circular line, so that the force needed to produce the plastic flow of material is considerably lower. Practical tests have proved that this process of working means a decrease of about 25 per cent in unit forming pressures when compared with the process employing slugs as a base semi-product.

(f) Another advantage of using rings as a semi-product is the fact that the edges of the extruded part remain slightly rounded and need not be subsequently chamfered.

(g) Mechanical presses are generally best suited for cold forming in dies because of their higher speed of forming and a greater number of strokes in comparison with hydraulic presses. The Czechoslovak LU type mechanical presses which are made for nominal pressures of 63, 100, 160, 250, 400, 630 and 1000 tons are best for this purpose. They are constructed from standardized groups and may be combined and suitably arranged for all sorts of characteristic pressing techniques.

(h) Most of the rotary-shaped parts may be produced directly by working close to the required shape and size. In some parts all that is needed is face smoothing or cutting of threads. The cold deformation increases the strength of material up to 60-80 kg/mm^2

so that heat treatment may be dispensed with. The extruded parts may be hard-faced by carburizing or quenching.

(j) As an example we may mention e.g. the production of gear rims for bicycles, which were formerly produced by machining forgings on automatic lathes. The costs of pressing from rings amount to only 40 per cent of the cost of the older production process.

Another example:

(k) One of very costly finishing operations is the smoothing of holes. An advanced technique for sizing and smoothing holes is represented by pushing a tapered broach or a ball through a hole of a smaller diameter. By pushing a tapered sizing broach surface finish of 0.1 - 0.2 μ can be attained. The operation takes only a few seconds. The necessary equipment is simple and does not require skilled attendance. This technique requires the straightness of the hole to be observed already in the preceding production operations. The wall-thickness should not vary along the length. It is also possible to make use of pulse-working for smoothing holes, when the tool (broach) is pushed into the hole by pulses and performs the following operations: rough-forging the hole connected with an effective strengthening of its surface, then finishing the hole by cutting off the allowance in several stages and final sizing and smoothing. For this technique the pulse-press LVI 50 is used.

(l) A similar technique is used for pressing the lining into the bearing bush. The lining material - a thin sheet up to 1 mm - is cut out, bent to shape and inserted into the rough-machined hole of the bearing bush with a tolerance of H 11 and with a surface finish of H_{sk} 25-50 μ. The lining is about 2-3 mm longer than the bearing bush and one side is flared so that it will be held by the front face of the bearing bush at the beginning of pressing. The longitudinal seam of the lining is not welded because the gap will be completely filled up by pulse-pressing. The forging-in of the lining is done by means of the tool described and on the LVI 50 pulse-press. The pressing operation takes only a few seconds. The precision is within the tolerance-limits of H6 - H7 and Hsk 0.02 - 0.05 μ surface finish is obtained.

4. Welding

(a) Welding is one of the most efficient joining techniques and its share in the mechanical engineering production will be steadily increasing.

(1) Arc Welding

a. Manual Welding

i. Though automation and mechanization of welding processes have made rapid advances, manual welding still plays an important part . This fact entails the necessity to increase the productivity of manual welding by increasing welding performance and depth of penetration.

ii. For this reason, in the Czechoslovak Socialist Republic, the EV-19 electrodes with a large yield of weld metal were developed and introduced into production. These are up-to-date high performance electrodes. Their higher welding performance is reached by means of a high arc voltage of 40 - 55 V and of an increased current density in comparison with electrodes of the classical type. The welding performance is 150-200 per cent higher than with normal electrodes. The speed of welding is 40-50 cm/min. Either D.C. power units with steep static characteristics or transformers with open circuit voltage of approx. 80 V are used as source of welding current.

iii. Deep penetration welding is another highly efficient technique of manual welding where high productivity is achieved by increasing the penetration depth in a chamferless joint gap. This welding technique is especially suitable for butt weld joints from 5 to 25 mm on rimming carbon steels containing up to 0.22 per cent of carbon. The savings in production costs in the case of butt joints amount to 50-55 per cent.

iv. Both these electrode types will substantially increase the productivity wherever favourable conditions for economical use of automatic arc welding machines have not been created or where automatic welding cannot be used at all.

b. Semi-Automatic and Automatic Welding

i. Automatic submerged arc welding is already well known. Recently even higher alloyed steels have been welded and gradually also submerged arc welding of aluminium is being applied in practice. A.C. is mostly used for this welding technique, D.C. is applied only in some special cases. The economic effect is greatest in the welding of sheets over 10 mm thick. The mechanical properties of the weld joints are equal to the base material characteristics.

ii. Automatic CO_2 shielded welding is rapidly becoming widespread in different branches of industrial production. It has some peculiar features in comparison with submerged arc welding. The CO_2 protective atmosphere has an oxidizing character and consequently some elements are burnt out. Therefore welding wires used for plain low-carbon steels must have increased contents of manganese and silicon in order to obtain the required composition of the weld metal. Welding wires of 0.8 to 2 mm dia. are used.

iii. CO_2 welding is suited for butt and fillet joints of up to about 15 mm thickness. The productivity in this field is about 50 per cent higher than in manual welding.

iv. Actual welding times in either of the two automatic welding techniques are on the average 10 times shorter in comparison with manual welding. An increase in productivity of labour as a whole is in most cases two- up to fourfold; this is due to relatively high preparing times which are higher than in manual welding.

(ii) Electro-Slag Welding

a. This method is economical for welding materials over 20 mm thick (thickness is practically unlimited). The weld pool which is formed between the two welded edges is shielded by molten slag and copper shoes are provided on both sided so that the pool cannot flow out. One or more electrodes, depending on the thickness of the material to be welded, are used. The electrodes have the shape of circular rods or strips. Welds are performed in a vertical position. The

advantages of this welding technique are great. The whole thickness of the material is welded in one single run. Electro-slag welding is used for welding the heaviest products such as e.g. thick-walled pressure vessels for the chemical industry, high-pressure boiler drums, heavy frames of forming machines where it has fully replaced the former heavy forgings or steel castings.

b. In the Czechoslovak industry the VUS-AS-4 type universal automatic electro-slag welding machine is used for welding in vertical position for wall thicknesses of 20 to 350 mm and weld lengths up to 5 m. In comparison with the present submerged arc welding techniques, the flux consumption of this new automatic welding machine is 20 times, electric power consumption 30 times lower and welding wire savings are 40 per cent. The productivity of labour is increased by 300-500 per cent. The automatic welding machine AS 4 replaces the work of 15 to 20 welders and, in the case of greater thicknesses, even of as many as 60 welders.

(iii) Resistance Welding

a. Resistance welding is the most efficient technique for joining materials; its use is now spreading even in production branches where formerly resistance welding had not been considered.

b. In production branches where welding had already for a long time played a decisive role, as e.g. in the automobile and railroad vehicle production industries, resistance welding is being applied in an ever increasing extent especially in the form of ultraspeed and multiple spot welding machines, welding presses mostly provided with electronic control equipment and with the possibility of programming the whole welding process and thus eliminating the influence of the human factor.

c. Mass production offers the most advantageous use of resistance welding. The application of programme-controlled automatic resistance welding machines is the way to high productivity and to the cutting down of production times.

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